Study and Design of Tall Office Building Power Plant

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STUDY AND DESIGN
OF
TALL OFFICE BUILDING POWER PLANT.

A THESIS -- PRESENTED

by

Warren E. Hill.

to the

PRESIDENT AND FACULTY

of

ARMOUR INSTITUTE OF TECHNOLOGY.

For the Degree

of

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING.

Having completed the prescribed course of study

in

MECHANICAL ENGINEERING.

Chicago, Illinois, June 15, 1905.

Approved W. F. Ickland

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STUDY AND DESIGN OF TALL OFFICE BUILDING POWER PLANT (HEYWORTH BUILDING)

The power plant chosen for this Thesis represents the most modern of office building power plant installations.

The Heyworth Building constructed this year, rises eighteen stories and attic above, with three separate basements below the City street level. The building situated at the Southwest corner of Madison Street and Wabash Avenue extends along the former street a distance of one hundred ninety six feet and along the latter one hundred feet. It has thus fully exposed sides to the North and East and with an alley on the West side is only slightly protected on that side from the weather. Above the tenth floor the building is entirely exposed on all sides. The first basement, the floor of which is fourteen feet below the street level, is occupied by a restaurant, while the two sub-basements, each twelve feet in heighth, are partially occupied by the power plant.

Electric lighting, heating and elevator service, are the chief consumers of power, and it was the object of this Thesis to become familiarly acquainted with the location and manipulation of the machinery and to offer a duplicate detailed design of the plant.

Six plates of drawings are enclosed in this Thesis, titled as follows:

PLATE 1. Preliminary project.
PLATE 2. Detailed plan of steam and exhaust piping.
PLATE 3. Detailed elevation of steam and exhaust piping.
PLATE 4. Detailed plan of water and steam heat piping.
PLATE 5. Detailed elevation of water and steam heat piping
PLATE 6. Detailed plan and elevation of elevator system.

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The boiler room containing the boilers, expansion tank, feed water heater, house pumps, feed pumps, vacuum pumps, steam heat return header for the one pipe return steam heat system, vacuum return header and condenser for Dixon vacuum heating system, Shone ejector pit, blow off and cooling catch basins, fresh air and exhaust fans and motors, and other small apparatus, occupy the floor space of about thirteen hundred square feet in the second sub-basement. A branch of the subway railroad enters at the Northeast corner of the building and this apartment, in front of the boilers.

The elevator pumps, accumulaters, surge tank and filter cover a floor area of about twenty four hundred square feet immediately to the east of the boiler room and at the same floor level.

The boiler room and a portion of the elevator pump apartment have a ceiling height of twenty two feet, with a portion of the pump room occupying the auxiliary pumps only ten feet in height.

The Shone compressor and air pressure tanks for that system and storage of air for other purposes throughout the building and power plant are situated in an apartment ten feet in height extending along south of the elevator pump and boiler room, doors leading to and from these apartments.

The engine room occupies a floor space of about twelve hundred and eighty square feet to the east of the elevator pump room in the east sub-basement, with a height to the ceiling of about ten feet. Immediately north of the engine room about five hundred and sixty square feet is allotted to the refrigerating plant and still to the north of the engine room and west of the refrigerating plant about six hundred and eighty square feet of floor space is occupied by the elevator pilot valve pumps and the engineer's office.

Along the south wall of the building in the first sub-basement separated from the power plant by a ten foot hallway, is situated an apartment five feet wide by sixty feet long and ten feet high in which the pilot valves are situated side by side beneath their respective elevators.. To the west of this apartment is situated a pipe shaft extending to the roof along side of the freight elevator shaft.

A platform of about six hundred twenty-five square feet area at the first sub-basement floor level extends along to the west and south walls behind the boilers, on which are situated the air wash coils and blowers and motors used in connection with the induced system of heating.

The boilers installed are three in number, two placed in one setting and one singly, of the Babcock & Wilcox water tube type. They are specially designed to carry a steam pressure of two hundred pounds to the square inch and are each equipped with a Mckenzie shaking grate furnace. This grate extends six feet in front of the boilers and smokeless combustion is guaranteed upon the principle that since the gases are impinged upon the incandescent fire arch they are entirely burned before smoke is formed. They are handfired grates, the shaking being manipulated by the firemen by handles extending out in front of the furnaces. Coal is conveyed to the boiler room into a space of about eight hundred square feet area directly in front of the boilers, through coal holes in the sidewalk above at the street level. The ashes and other refuse of the power plant are conveyed to a subway car, left standing in the Northwest corner of the basement, a few feet distant from the boilers, and removed by that route. The boiler breeching five foot square extends along the rear, near the top of the three boilers, four foot square connections dropping down to each of the boilers. The breeching terminates in a

six foot diameter smoke stack, extending up to about six feet above the roof of the building.

Steam is conveyed through eight inch, long sweep bend steam leads from each boiler to the twelve inch main header extending along in front of the boilers. Referring to Plate 2, it may be observed that from this steam header a nine inch steam loop extends over the elevator pump and engine room and returning again terminates in the main header. A six inch auxiliary header connects the two sides of the loop near the boilers. (also) All steam supply pipes have long sweep bends of a radius equal to five times the diameter of the pipe. The main header is drained at each end by a one and a half inch pipe leading to the high pressure drip tank.

A twelve inch exhaust line leading from the engine terminates with an eight exhaust from the elevator pumps and a fourteen inch pipe leading to the expansion tank. Medium sweep bends of a radius equal to twice the diameter of the pipe are used in the exhaust lines. All the larger sizes of steam and exhaust pipe have flanged fittings throughout and are supported by uprights rising from the floor. These supporters consist of steel rollers placed in a loose bearing screwed into a cap (plate) placed on a five inch pipe, the pipe being securely fastened at the lower end to the floor.

Before all steam consuming apparatus in the power plant are situated Austin steam separators from which one-half inch pipes lead as high pressure drips to the high pressure drip tank. All these high pressure drips with the drips from the steam header flow through throughaone and one-half inch pipe laid in a gutter below the floor and covered with iron floor plates, leading to the high pressure drip tank situated near the boiler below the floor. A one inch pipe leads from this high pressure drip tank out over the boilers and terminates in a Holly header situated in the pipe shaft at the second floor.

The return pipe from the Holly header terminates in a line behind the boiler, leads with valves from this line entering one shell of each boiler, so that the high pressure drips finally enter the boiler.

The low pressure drips consisting of the cylinder, exhaust pipe and receiver condensed steam enter pipes also laid in the gutter and flow into a low pressure drip tank situated in the same pit with the high pressure tank, and through a three inch extra heavy galvanized pipe the contents of this tank gravitate into the blow off basis situated behind the boiler. A five inch vent pipe connecting the blow off basin and low pressure drip tank extends to the pipe shaft and terminates at the roof in an exhaust header.

Four inch blow off pipes with two valves lead from each boiler into the blow off basin and this condensed steam with that from the low pressure drip tank, gravitate through a four inch galvanized pipe into a cooling catch basin. Other washings from throughout the engine and boiler room gravitate into a third catch basin and from there into the cooling basin, where all are allowed to cool before entering the Shone ejector to be discharged into the sewer..

The Shone system of sewerage and drainage is widely adapted in power plants because of its sanitary efficiency and its certainty of operations under adverse conditions with very little attention. The operating power employed is compressed air, supplied to a closed pressure tank at from fifteen to twenty pounds pressure. In this plant there are two-eight by six inch single (double acting) cylinder compressors driven through Morse silent chain drives by two Crocker Wheeler five horse power compound wound motors run at one hundred and ten volts and nine hundred and eighty revolutions per minutes.

Two ejectors are located side by side in the pit each having a capacity of fifty gallons per minute against a fifty foot

(ing a capacity of fifty gallons per minute against a fifty foot) head. An inlet pipe connecting the two ejectors extends across the pit at one side while on the opposite dide a discharge pipe connecting the two, leads out beneath the floor finally terminating in the City street sewer. As soon as the ejector is filled by the sewage and drips flowing into it from the cooling basin, compressed air from the tank spoken of is automatically admitted which at once forces out the contents through the discharge pipe, thus emptying the ejector. The compressed air is then cut off automatically and that inside the ejector allowed to escape to a point outside the building, whereupon the process is repeated. A cylindrical steel tank in the engine room is also connected by a line of one inch pipe with the air pressure tank already mentioned so that by means of leads of hose air may be used for blowing out the main generators.

In the same apartment with the Shone compressor is located a third air compressor operated independently by a third motor. This air is used for supplying small amounts of power to jewelers and for the use of dentists and doctors so that a circuit of one inch pipe extends around through the three upper stories of the building, all the offices on those floors having one half inch connection. As this air is required to be as pure as possible no oil lubrication is permitted in the compressing cylinder. Thus we have an eight inch by eight inch compressor with a lignum vitae piston which is lubricated by injection of water into the cylinder. The air receiver has two coils in it through which the returns from the ice drinking water pipes flow so that the water is thereby condensed out of the air and finally removed with the injection water by means of a trap. A switchboard with automatic controlling devices and pressure gauges attached is also located in this apartment.

Three Fleming thirteen inch by twenty inch by thirteen inch high speed cross compound engines direct connected to Crocker & Wheeler generators generate electric power for the lighting of the building and supply of auxiliary motors used throughout the building and power plant. The generators are rated at 100 K.W. at 125 volts and 100 amperes, at 275 revolutions per minute.

The engines are oiled by means of a circulation automatically regulated by a pump attached to the cross head of the engine, the oil after passing over the bearings being finally collected and filtered and again placed in circulation.

Feed water is supplied to the boiler through a duplicate system of piping from either of two, seven and a half inch by five by six inch Deane compound duplex steam pumps, having a four inch suction and three inch discharge. By manipulation of valves cold filtered water may be drawn from the surge tank or as is generally the case heated water may be drawn from a Cookson open heater. Two, three inch discharge pipes lead up from each pump and entering two common headers a by-pass system of feed water piping is formed. The two lines run parallel across the top of the boilers near the front and a two inch lead with valve is taken from each pipe, terminating in a common feed line to each boiler shell.

Water for house purposes is pumped by either of two electrically driven Rumsey five inch by eight inch double geared triplex power pumps of a ready capacity of one gallons per minuts to either of two cylindrical steel house tanks eight foot in diameter by eight feet high situated in the pent house on the roof. These pumps are electrically started and stopped and may draw filtered water direct from the surge tank or city water from another cylindrical steel tank, five foot in diameter by six feet in height located in the refrigerating room.

Hot water for the tenants is furnished by a Tobey automatic water heater suspended from the ceiling of the boiler room. This heater consists of an upper and lower chamber, the lower containing the heating surface, consisting of a number of copper tubes fastened into a plate held in place between a cap and flange. At the opposite end the tubes are screwed into a header in which there is a pipe to receive the steam valve connection, steam in this case being received through a steam line from the expansion tank. The upper or expansion chamber contains a perforated copper tube rigidly fastened at one end of the heater and connected at the other end to a spindle, which on expansion or contraction of the tube acts on the lever and thus opens or closes the balanced steam valve. Water is supplied to the heater through a cold water inlet from the house tank and upon being heated by contact with the tubes in the lower chamber it rises and passes out through the copper tube to the faucets throughout the building. Thus the heat of the water is automatically adjusted.

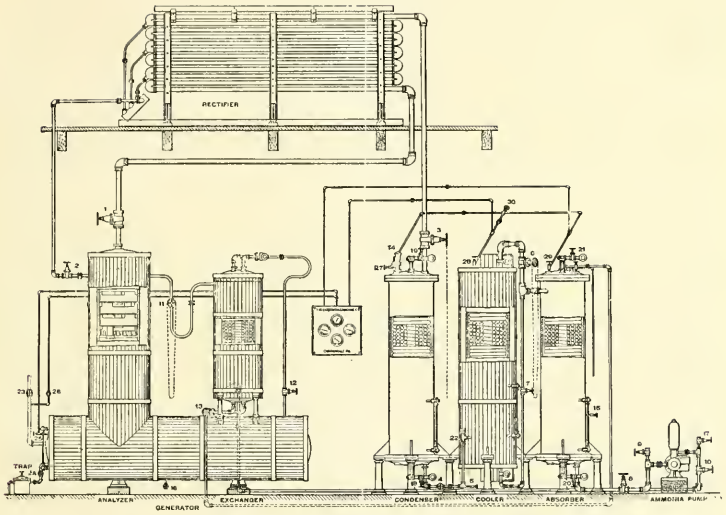
All water to be used for any purpose upon passing through the city meter may pass direct into the closed steel surge tank and without being filtered pass through the feed and house pumps or by means of valves it may be first passed through a bed of sand within the filter and then passed into the surge tank from which the feed and house pumps may draw it. A water headed is situated above the surge tank from which leads run out, one to the feed water heater, another to the refrigerating supply tank and a number of others to drinking and washing faucets throughout the building. The feed and house pumps draw directly from the surge tank.

A Carbondale absorption refrigerating system is installed for furnishing ice drinking water. All the water to be used for drinking purposes after being filtered enters the steel tank situated in the refrigerating room previously mentioned.

Float valves keep the water level at a proper height in this tank any surplus water being discharged into the sewer. Water from this tank passes into the cooling tank as it is needed where it is cooled to the proper temperature for drinking by coils passing through it. The filtered water as it is cooled is pumped by an electric driven pump to a closed tank in the attic from which it is distributed throughout the building at a pressure due to that head.

Referring to the enclosed sketch of a plant identiaal to that installed in the Heyworth Building a description of it is here offered. The power utilized in the refrigeration originates in the still, consisting of a castiron shell laid horizontally with a tee opening near one end. The body of this shell is partially filled with steam pipes which are kept submerged in a strong solution of aqua ammonia. Exhaust steam from the feed pumps reinforced when necessary by steam from the live steam line to the feed pumps, circulates through these steam pipes. The heat thus conveyed to the ammonia liquid causes it to boil and the ammonia to rise off in the form of gas under a high pressure. The condensed steam passes into a trap to be finally discharged into the sewer.

At one end of the still rising vertically is a cylindrical iron shell called the analyzer. This shell is partially filled with perforated ~~xitx~~ castiron trays so constructed as to allow the hot ammonia gas generated in the still to rise through them, while at the same time they convey through separate openings the incoming supply of strong aqua ammonia, returning from the ammonia pump, which now being cooler than the rising gas causes the water vapor to precipitate. The hot gas passes from the top of the analyzer to the rectifier, a steel tank suspended from the ceiling and containing slightly cooled water. The gas passing through coils situated in this tank



THE CARBONDALE REFRIGERATING MACHINE.

THE CARBONDALE MACHINE CO.,

CARBONDALE, PA.

has the remaining water in it condensed.

Leaving the rectifier the warm anhydrus ammonia gas goes to the condenser, which is in direct communication with the previous mentioned parts, so that the pressure of the gas within this tank is the same as that in the still. The condenser consists of a number of coils through which cool water is circulated, and as the ammonia gas enters this apartment and comes in contact with the cool pipe it condenses to a liquid and falls to the bottom of the shell as anhydrous ammonia, still under the high pressure. The liquid is now ready to be used as a refrigerating agent. It has a boiling point of twenty-right and six tenths degrees below zero at atmosphere pressure so that now as a liquid under a high pressure it is allowed to flow from the bottom of the condenser through a finally adjusted valve into the cooling coils leading through the cooling water tank, which has a much lower pressure than that of the liquid in the condenser. Thus as the valve is opened slightly the pressure of the out-going liquid is so far lowered that it rapidly evaporates and boils itself into a gas taking heat from the water surrounding the coils to accomplish that end. Thus the water is cooled to any degree desired by manipulation of the reducing valve, and the gas leaving the cooling coils is heated by this water and passes to the absorber.

As before mentioned a portion of the aqua ammonia, being weaker, and thus heavier than the strong aqua ammonia in the still it settled to the bottom as soon as the steam heat was applied to it and its gas driven off. Thus we have a weak solution of aqua ammonia at a high pressure at this point and in the absorber, we have the heat ladened anhydrous ammonia gas whose cooling qualities have been utilized. The weak ammonia liquid is then forced out of the still by its own pressure to the top of a set of coils passing through the second vertical cylinder

situated on the still. Here a heat exchange takes place betwen the hot weak ammonia solution just mentioned coming from the still, which is decending to the exchanger, and the strong aqua ammonia passing up on the outside of the coils coming from the absorber through the ammonia pump and on its way to again be heated in the still.

Passing from the coils of the exchanger the weak aqua ammonia is taken to the top of the absorber previously mentioned and sprayed over the hot gas coming from the cooling coils. The hot ammonia gas is at once absorbed into the weak aqua ammonia solution which results in a strong solution of that liquid, which falls to the bottom of the absorber and is ready to be pumped by the a monia pump back through the exchanger to the still.

The cooling water passed up through the condenser coils passes through the absorber coils and rectifier coils in turn after which it is discharged into the house supply tank.

Four methods of steam heating may be operated in this building, the Dixon vacuum system, a one pipe return system, a vacuum system similar to the Webster system and induced heating by means of blowers.

The sub-basements and basement are heated by the induced system. For this system there are two exhaust and one fresh air blower driven by motors. Air is drawn in from without the building and passed through a spray of water in a sheet iron chamber before passing through the fresh air fan and heating coils into the mixing chamber, from whence it is forced through the heating ducts. The temperature of the air maybe varied in the mixing xhamber to suit the weather so that in the summer a cool temperature may be acquired and in the winter any degree of heat may be obtained.

It is intended that the first floor and remaining floors of the building shall be heated regularly by the Dixon vacuum

system of steam heating although the piping is so arranged that a system similar to the Webster system may be used and also if need be a one pipe return system may be used.

The first floor of the building consisting of stores and open hall ways has an independent steam line so that it may be heated by either of the three mentioned systems. The remaining stories are heated from the attic distribution through the risers.

The exhaust steam from all engines and pumps flows into the expansion tank, a steel cylindrical closed tank four foot in diameter and fourteen feet long situated in the boiler room. A fourteen inch exhaust header enters this tank carrying all exhaust steam from the pumps and engines. A small line passes out to the Tobey hot water heater, a five inch line to the fan coils for induced heating, and a six inch line to the Cookson heater for feed water heating purposes.

A fourteen inch pipe with an atmosphere relief valve in it passes from the tank up the elevator shaft and terminates in an exhaust header, when the exhaust not entirely used for other purposes may pass to the atmosphere. A six inch high pressure supply pipe enters the tank from the main steam header to make up any deficiency of steam as may be necessary in extremely cold weather.

The three remaining out-going pipes from the expansion tank convey steam to the various steam heating leads. One four inch lead passes around one side and end of the basement as a supply to the first floor system and a six inch lead passes around the opposite side and end as a second supply for the same system.

A sixteen inch line passes along side (~~side~~) the atmosphere line to the attic where it terminates in a sixteen inch loop header which passes around the attic with risers leaving it at

regular intervals and continuing downward to the basement and terminating in corresponding return headers.

These return headers collecting all the water returns from the first and remaining stories when the ordinary one pipe system of heating is used finally terminate in a return header, a pipe about ten feet long and eight inches in diameter. The returns from the fan coils and the Tobey hot water heater also enter this header, and may be passed from there by gravity either into the hot water heater or be discharged into the sewer. The expansion tank itself is drained by a trap which also discharged into the sewer.

For the Dixon system which is expected to give the best satisfaction, the steam is supplied to the radiators in the same way through the attic loop distribution, but the return headers are cut out and the water returns are discharged by a small line passing down from the upper floors alongside each riser, into a surface condenser. The steam being drawn into the conderser and condensed a vacuum of as high as twenty five inches may be formed and so very little back pressure placed on the steam apparatus throughout the plant. The air and condensed returns are pumped from the condenser through a Knowles six inch by nine inch by ten inch vacuum pump to the top of the heater, from whence the air is released by a vent valve with other air entrapped in the heater. The condenser may be cut out also by a by-pass and the system operated on a principle similar to that of the Webster System by means of the vacuum pump forming the necessary vacuum. The warm water passing through the surface condenser passes up to the Tobey hot water heater to be more highly heated for house use.

A Cookson hot water heater and purifier with filter and oil separator attached is used in this plant, through which the boiler feed water is caused to pass. Only enough steam is admitted to the heater to heat sufficient feed water for the

boilers. The exhaust steam from the expansion tank is admitted to the heater near the top, and upon entering it strikes a set of V shaped oil separating plates which divides the volume of the steam, the ribs on these plates catching the oil and moisture in the steam, the separation of the moisture being completed when the steam expands in the chamber. The steam then rises through an enlarged portion of the exhaust chamber and again impinges upon a second set of V shaped plates opposite to the first set causing further separation of the oil From here when the heater is used as a through heater the steam is passed to the steam heating system. The air collected within the heater is allowed to pass off through the vent pipe previously mentioned. The cold water flowing from the filter or surge tank now enters the top of the heater and being turned into a spray condenses the steam in the upper chambers, forming a vacuum which draws up the required amount of steam from the expansion tank. The water supply from the filter or surge tank is regulated by a water regulator so that a uniform height of water is maintained in the heater. The oil separator apartments discharge the oil collected into traps and finally into the sewer. The feed pumps draw the boiler feed water from the heater at a temperature of about two hundred and ten degrees.

Nine high pressure vertical multiple sheave elevators have been installed in this building by the Otis Elevator Company. Of these eight are for passenger service and one for freight. Of the eight passenger elevators five run to the eighteenth floor while all run as high as the tenth. The travel of all the elevators is multiplied five times by the arrengement of the ropes running from the plunger over the sheavesand finally to the elevator.

The working pressure of this system is eight hundred and eighty pounds per square inch, less one hundred and thirty pounds per square inch back pressure gives seven hundred and

fifty pounds per square inch absolute pressure and this pressure acts on the plunger within the elevator cylinder and the elevator rises as the plunger decends.

Referring to Plate 6: A fourteen inch by seventeen inch by seventeen inch by four and seven-eighths inch by twenty-four inch, three cylinder compound single acting Corliss pumping engines is used regularly to maintain the eigh hundred and eighty pounds pressure against two, thirty inch accumulators. This pump is built for a capacity of three hundred and thirty gallons per minute at fifty eight R.P. M. against seven hundred and fifty pounds discharge pressure, with a hundred and thirty pounds back pressure on a suction and with steam at one hundred and forty pounds per square inch pressure at the throttle. The engines for the pump consist of three Corliss steam cylinders side by side with a high pressure cylinder in the middle and the low pressure cylinders on either side working directly through the piston rod on single acting outside end packed water plungers. The piston and water plunger loads are equalized by means of two large fly wheels driven through links, rocker beam, and connecting rod from the cross head located between the steam and water cylinders. The pump end is so arranged that the motion of the water is constantly in one direction. Seven valves are provided in each of six valve pots and are of the wing type with fiber faces working on bronze sheets.

To alternate with this Laidlaw Dunn Gordon Pump are installed two, 18 " X 29" X 8 3/8" X 24" tangem compound outside packed plunger type Blake pumps. All these elevator pumps are necessarily automatic in their action to meet the varying water requirement, and for this purpose chronometer valves placed in the steam line of each of the pumps are so connected by ropes to the accumulators, from which the water is supplied

to the elevators, that the travel of the accumulator to its highest position will shut off the supply of steam to the pump engine causing them to stop and a drpp in the accumulator will cause the valves to open. In order to insure that the pumps themselves will start up from any position when the chronometer valve is open, a special automatic check valve and by-pass arrangement is fitted to the pump end which equalizes the pressures in the pump for an instant when necessary.

Following the travel of the water upon being pumped by the pumps to the accumulator, it passes through an air chamber twelve inches in diameter and sixteen feet high. To furnish an air cushion for this chamber and for the cushion and discharge water tank, two Westinghouse air compressors are used which are capable only of working against a pressure of about one hundred and fifty pounds per square inch, so that although the suction air chamber may be filled directly by the pump, yet the hight pressure chamber has to be filled by another method. For this purpose a cylindrical steel tank about four foot long and nine inches in diameter is connected with the air compressor line while another pipe and valve lead from the tank to the pressure regulating apartment. To send air into the air chamber the tank is first filled at one hundred and fifty pound pressure after which the valve in that line leading to the compressor is closed and the valve leading to the air chamber open. The water than flows into the air tank due to the difference of eight hundred and eighty and one hundred and fifty pound pressure until the pressure is equalized, when the air will rise in the air chamber situated in the high pressure line. This process may be repeated until a sufficient quantity of air is obtained, the water in the small tank being finally discharged into the large elevator suction tank.

Two accumulators are placed in the high pressure line each working between different pressure, so that when the

system is in operation one accumulator is always at its highest position, while the other takes care of the varying pressure. Thus in case of an extra amount of water being used the high pressure accumulator may descend entirely and the other will hold up the pressure until the pumps pick up.

The water at eight hundred and eighty pounds pressure passes out through the pipe leading to the pilot valves. These valves, one for each elevator are placed in line along ~~of~~ side of each other directly under their respective elevators. The pilot valve as it is named consists essentially of a piston and two valves and is arranged so that the flow of the high pressure water to and from the elevator cylinder may be varied. Referring to the sketch of this valve on Plate 6, the valve to the right resembles a steam valve without laps, and is operated by the exhaust water coming from the elevator cylinders. This valve always moves slowly and is operated by the car driver by means of a rope running over pulleys and through the car. As the valve is opened water at one thirty pound pressure enters either side of the valve and flows through the valve into the cylinder causing a movement of the adjacent piston accordingly. A piston rod passes through this piston and at either end is firmly connected to the water valve proper so that as the piston valve moves so does the water valve. The low pressure valve is also connected by a link motion to this piston so that the slide valve is immediately brought back to its central position when the water piston has attained its proper position to admit or allow water to flow to the elevator cylinder. Thus after every movement of the water valve and piston the low pressure valve is brought back to its central position and is ready to be moved again in either direction to admit or discharge the water in the elevator cylinder.

Now since the direction of the flow of the water in the

cylinder depends upon the position of the high pressure valves, the operator can cause any opening desired of the valves and consequently determine the movement of the car.

Since when the elevator may be rising at its highest speed the supply water may be suddenly cut off, the inertia of the plunger and moving parts will carry the plunger on some distance causing it to leave the water. As the weight of the elevator gradually overcomes that of the plunger, the elevator will fall after the flow is shut off and this action will occasion what is termed "bouncing". This action is prevented by a chedk valve placed in the pipe connecting the suction and high pressure lines so that as the plunger leaves the water the check valve is opened and water flows in behind the plunger

The discharge water from the pilot valve at atmosphere pressure is forced into a rectangular tank two and a half feet by five feet by six feet high, situated over the two Blake elevator pumps, while the remainder of the discharge water is forced to an open steel elevator discharge tank, six foot square by six feet deep, situated in the attic, the head from this tank causing the one hundred and thiry pounds per square inch back pressure on the elevator pumps.

The discharge or suction water, as it may now be called, gravitates to the closed suction tank a steel cylindrical tank situated close to the elevator pumps from which they again draw the water for the system.

Either of two 9" X 14" X 7" X 10" tandem compound Worthington steam pumps, designated as pilot pumps are used to draw the pilot valve water from the open tank mentioned and discharge it into the suction tank against the hundred and thirty pound pressure. An air cushion is also maintained in this tank..

For specially heavy loads the freight elevator cylinder receives its water through a special line of pipe at two thousand pounds per square inch pressure from a Laidlaw Dunn Gordon 10" X 3" X 10" simple duplex pump. Under ordinary loads, however, the freight elevator works under the same pressure and from the same supply as the passenger elevators.